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IS 14329 (1995): Malleable iron castings [MTD 6: Pig iron and Cast Iron]



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भारतीय मानक
आघातवर्ध्य लोहे की ढलाइयां — विशिष्टि

Indian Standard
**MALLEABLE IRON CASTINGS —
SPECIFICATION**

ICS 77.140.80

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Pig Iron and Cast Iron Sectional Committee had been approved by the Metallurgical Engineering Division Council.

The committee, while reviewing the following three standards on malleable iron castings, decided to amalgamate them into one standard:

IS 2107 : 1977	Whiteheart malleable iron castings (<i>first revision</i>)
IS 2108 : 1977	Blackheart malleable iron castings (<i>first revision</i>)
IS 2640 : 1977	Pearlitic malleable iron castings (<i>first revision</i>)

In preparation of this standard, necessary assistance has been derived from ISO 5922 : 1988 'Malleable cast iron' issued by the International Organization for Standardization.

Annexes A, B and C have been incorporated giving the typical properties of whiteheart, blackheart and pearlitic malleable iron castings and are for information.

This standard contains clauses 6.7.1, 9.1, 13.4, 14.1 and 15.2 which require the purchaser to specify his requirements, if necessary, while placing an order.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

MALLEABLE IRON CASTINGS — SPECIFICATION

1 SCOPE

This standard covers the requirements for malleable iron castings. It is applicable only to malleable iron castings obtained through sand moulds or moulds of comparable thermal diffusivity.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	Title
397 (Part 1) : 1972	Method for statistical quality control during production: Part 1 Control charts for variables (<i>first revision</i>)
786 : 1967	Conversion factors and conversion tables (<i>first revision</i>)
1387 : 1993	General requirements for the supply of metallurgical materials (<i>second revision</i>)
1500 : 1983	Method for Brinell hardness test for metallic materials (<i>second revision</i>)
1608 : 1972	Method for tensile testing of steel products (<i>first revision</i>)
1757 : 1988	Method for charpy impact test (V-notch) for metallic materials (<i>second revision</i>)
4843 : 1968	Code for designation of ferrous castings
8349 : 1977	Deviations for untoleranced dimensions of malleable iron castings
13655 : 1993	Guidelines for heat treatment of cast iron

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Malleable Cast Iron

Malleable cast iron is a heat treated iron carbon alloy, which solidifies in as cast condition with a graphite free structure, that is, the total carbon content present in the combined form as cementite (Fe_3C).

3.1.1 Malleable iron castings may be either whiteheart, blackheart, or pearlitic according to the chemical composition, temperature and time cycles of the annealing process, the annealing atmosphere and the properties and microstructure resulting therefrom.

3.2 Whiteheart, Malleable Iron Castings

Whiteheart malleable iron castings obtained after annealing in a decarburizing atmosphere have a silvery-grey fracture with a heart darkgrey to black. The microstructure of whiteheart malleable cast iron is dependent on section size, as follows:

- a) Small section size: — ferrite(+ pearlite + temper carbon)
- b) Large section size:
 - Surface zone — ferrite
 - Intermediate zone — pearlite + ferrite + temper carbon
 - Core zone — pearlite (+ ferrite) + temper carbon

The microstructure shall not contain flake graphite.

3.3 Blackheart Malleable Iron Castings

Blackheart malleable iron castings obtained after annealing in an inert atmosphere have a black fracture. The microstructure developed in the castings has a matrix essentially of ferrite with temper carbon and shall not contain flake graphite.

3.4 Pearlitic Malleable Iron Castings

Pearlitic malleable iron castings obtained after heat treatment have a homogeneous matrix essentially of pearlite or other transformation products of austenite. Graphite is present in the form of temper carbon nodules. The microstructure shall not contain flake graphite.

4 GRADES

4.1 This standard covers the following grades of malleable iron castings:

Whiteheart malleable iron castings	: WM 350 and WM 400
Blackheart malleable iron castings	: BM 300, BM 320 and BM 350
Pearlitic malleable iron castings	: PM 450, PM 500, PM 550, PM 600 and PM 700

4.2 Grades are designated on the basis of minimum tensile strength in MPa. For example BM 350 denotes blackheart malleable iron castings with 350 MPa as minimum tensile strength

5 SUPPLY OF MATERIAL

General requirements relating to the supply of malleable iron castings shall be as laid down in IS 1387:1993.

6 MANUFACTURE

The method of manufacturing malleable iron castings, its chemical composition and heat treatment shall be left to the discretion of the manufacturer, provided the castings conform to this standard in all respects. However, for malleable iron castings to be used in special applications, the chemical composition and heat treatment may be the subject of mutual agreement between the manufacturer and the purchaser.

7 WORKMANSHIP AND FINISH

7.1 The castings shall be accurately moulded in accordance with the pattern or working drawings supplied by the purchaser with the addition of such letters, figures and marks as may be specified.

7.2 The purchaser shall specify tolerances on all important dimensions. For other dimensions, tolerances specified in IS 8349 : 1977 shall apply.

8 FREEDOM FROM DEFECTS

8.1 All castings shall be sound, clean and free from porosity, blow holes, hard spots, cold shut, distortion and other harmful defects. They shall be well dressed and fettled.

8.2 At the discretion of the purchaser, up to one percent of all castings submitted for inspection may be rough machined or subjected to destructive test by sectioning in order to ensure internal soundness.

9 TEST BARS

9.1 Provision of Test Bars

All test bars shall be cast separately. They shall be suitably marked so that the castings they represent could be identified.

NOTE — It is considered undesirable to cast test bars integrally with the castings. Only in special circumstances and by agreement between the purchaser and the manufacturer such integral test bars may be provided.

9.1.1 Test bars shall be cast in moulds of the same material and under the same condition as the moulds used for the castings they represent. They shall be cast at the same time and from the same melt as the castings they represent.

9.1.2 Test bars shall in all cases undergo the malleablizing heat treatment together with the castings they represent.

9.1.3 In the event of any further heat treatment, being given to the castings to meet the requirements provided under 9 , the test bars shall be suitably heat treated along with the castings they represent.

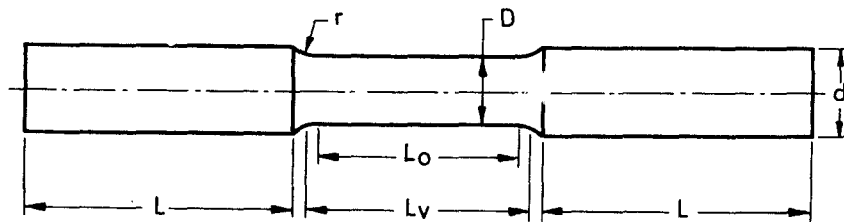
9.2 Dimensions of Tensile Test Bars

9.2.1 Tensile test bars shall be cast to the dimensions specified in Table 1. The dimensions of the shanks may be modified to suit the jaws of the testing machine.

9.2.2 The cast tensile test bars may be dressed or cleaned and shall be tested in the unmachined condition.

Table 1 Dimensions of Tensile Test Bar

(Clauses 9.2.1 and 10.1)
All dimensions in millimetres.



Nominal Diameter	Tolerances on Nominal Diameter	Shank Dimensions		Gauge Length ($L_0=3D$)	Length L_v	Radius at Shoulder r
		Diameter D	Length l			
(1)	(2)	(3)	(4)	(5)	(6)	(7)
9	+ 0.6 0	13	40	27	30	6
12	+ 0.7 0	16	50	36	40	8
15	+ 0.7 0	19	60	45	50	8

10 MECHANICAL TESTS

10.1 Tensile Test

A tensile test bar cast as far as practicable to the dimensions shown in Table 1 shall, when tested in accordance with IS 1608:1972 without any machining of the gauge length, give results not less than those specified in Table 2. Since the test bars are in unmachined state, they may not be quite circular, in which case the tensile strength shall be calculated on the mean diameter at the middle of the gauge length by taking two measurements at right angles, one of which shall be the maximum diameter.

10.2 Hardness Test

The Brinell hardness test when specified by the purchaser shall be carried out in accordance with IS 1500 : 1983. The hardness values shall be as specified in Table 2. The test shall be carried out at a given point(s) on the casting as agreed to between the manufacturer and the purchaser.

11 SAMPLING

11.1 For quality control during production, use of control chart techniques is recommended to the

manufacturer for which a reference is invited to IS 397 (Part 1) : 1972. The result of such tests conducted at the place of manufacture may be made available along with material supplied, to enable the purchaser to judge its acceptability.

11.2 Sampling for Chemical Analysis

Samples for chemical analysis shall be drawn either from a finished casting or a test bar for tensile test representing each heat or cast, as agreed to between the purchaser and the manufacturer.

11.3 Sampling for Tensile Test

Three tensile test bars shall be cast for every 1 500 kg (or part of 1 500 kg) of castings of each heat of cast, and heat treated in the same batch. From each set of these test bars, one tensile test bar shall be tested. The remaining two tensile test bars shall be reserved for the purpose of retest, if necessary, under 13.1 to 13.4.

11.3.1 When large tonnage of castings is produced, the minimum number of test bars to be provided shall be one set of three tensile test bars for each two hours of production from a melting furnace, but there shall be at least one such set of test bars for each heat-treatment batch.

Table 2 Mechanical Properties of Malleable Iron Castings

(Clauses 10.1, 10.2, 13.2 and 13.3)

Grade Designation (see IS 4843:1968)	Sectional Thickness Represented, mm	Diameter of Test Bar, mm	Tensile Strength Min, MPa	0.2 Percent Proof Stress, Min, MPa	Elongation (Lo = 3D) Min Percent	Hardness HB
(1)	(2)	(3)	(4)	(5)	(6)	(7)
WM 350	Up to and including 8	9	340	—	5	
	Over 8 up to and including 13	12	350	—	4	230 Max
	Over 13	15	360	—	3	
	Up to and including	9	360	200	8	
WM 400	Over 8 up to and including 13	12	400	220	5	220 Max
	Over 13	15	420	230	4	
BM 300	All sizes	15	300	—	6	150 Max
BM 320	All sizes	15	320	190	12	150 Max
BM 350	All sizes	15	350	200	10	150 Max
PM 450	All sizes	15	450	270	6	150 - 200
PM 500	All sizes	15	500	300	5	160 - 200
PM 550	All sizes	15	550	340	4	180 - 230
PM 600	All sizes	15	600	390	3	200 - 250
PM 700	All sizes	15	700	530	2	240 - 290

12 VALIDITY OF TESTS

12.1 A test may be disregarded if poor, results are obtained and are not due to the quality of the cast iron itself, but to any of the following reasons:

- a) Faulty mounting of the test piece or defective operation of the test machine;
- b) Defective casting or machining of the test piece;
- c) Fracture of the tensile test piece beyond the gauge marks or;
- d) Casting defects in the test piece, evident fracture.

12.1.1 In the above cases, a new test piece shall be taken from additional test bars provided under **11.3** and **11.3.1** and the result obtained substituted for those of the defective test piece.

13 RETESTS

13.1 Should any of the tests fail to meet the specified property requirements, two retests per failed test may be carried out.

13.2 The batch is regarded as conforming to the specified requirements when the results of the two retests conform to the value shown in Table 2. However, the batch may be rejected if one of the retests fails.

13.3 If the separately cast test bars are not available for further test then the test bars may be cut from the finished castings and the results so obtained shall be not less than 80 percent of all minimum values specified in Table 2.

13.4 When the shape and size of the castings does not permit preparation of such test bars, if agreed to between the purchaser and the manufacturer, one or more finished castings shall be submitted to an agreed microstructure and hardness test.

14 HYDRAULIC, STEAM OR AIR PRESSURE TESTS

14.1 Where hydraulic, steam or air pressure tests are required, these shall be subjected to mutual agreement between the purchaser and the manufacturer.

15 MARKING

15.1 Where practicable, each casting shall be legibly marked with an identification mark by which it is possible to trace the melt and the batch of heat-treatment from which it was made.

15.2 By agreement between the purchaser and the manufacturer, castings complying with the requirements of this standard shall, after inspection, be legibly marked with an acceptance mark.

15.3 BIS Certification Marking

The castings may also be marked with the Standard Mark.

15.3.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(Foreword)

TYPICAL PROPERTIES OF WHITEHEART MALLEABLE IRON

A-0 The following information is given for guidance to engineers and designers. It is not part of this Standard and should not be used for acceptance purposes.

A-1 MICROSTRUCTURE

A-1.1 The structure of whiteheart malleable iron may vary according to the thickness of the casting, the distance below the surface and the method of manufacture. Most of its properties vary in a corresponding way as outlined in this Annex. In thin sections and near the surface of thicker sections, there may be a complete absence of graphite and the matrix may contain no combined carbon; whereas in thicker sections the matrix may contain combined carbon in various forms.

A-1.2 Material complying with the requirements of this standard may show a dark or a light fracture.

A-2 COMPRESSIVE STRENGTH

The stress/strain properties in compression are similar to those in tension. The proof stress value in compression is, however, slightly higher than in tension because the onset of plastic deformation is delayed under compressive stress.

A-3 SHEAR STRENGTH

This is approximately 0.9 times the tensile strength.

A-4 TORSIONAL STRENGTH

The torsional strength is 0.9 times the tensile strength.

The proof stress value in torsion is 0.75 times the value in tension.

A-5 MODULUS OF ELASTICITY

A value of 175.8 kN/mm² is typical.

A-6 MODULUS OF RIGIDITY

A typical value is 70.3 kN/mm².

A-7 POISSON'S RATIO

A value of 0.26 is appropriate.

A-8 FATIGUE LIMIT (WOHLER)

The unnotched fatigue limit is about 0.45 times the tensile strength. The notched fatigue limit is about 0.6 times the unnotched fatigue limit.

A-9 HARDNESS

With the structure variation between edge and centre of sections, the hardness depends on the distance from the surface and the section thickness. Maximum hardness values up to 230 HB may be obtained in thick sections with values down to 220 HB in thin sections or at the surface of thick sections.

A-10 IMPACT PROPERTIES

Because of the variable structure across a section it is not usually possible to obtain a representative impact test specimen. However, irons containing considerable quantities of ferrite, generally in thin sections, have good ductility and toughness. In higher strength irons and thick sections containing more pearlite, impact transition temperature increase and some ductility and toughness is sacrificed to take advantage of the greater strength.

A-11 COEFFICIENT OF THERMAL EXPANSION

Up to 400°C the values will be about $10.0 \times 10^{-6}/^{\circ}\text{C}$ to $12.5 \times 10^{-6}/^{\circ}\text{C}$ the higher value being obtained at higher temperatures.

A-12 THERMAL CONDUCTIVITY

This will be within the range from 41.9 to 45.2 W/m°C up to 500°C. The value falls with increasing temperature.

A-13 SPECIFIC GRAVITY

The specific gravity may be expected to be 7.4.

A-14 SPECIFIC HEAT

This is approximately 0.46 J/g°C.

A-15 MAGNETIC AND ELECTRICAL PROPERTIES

The values are typical of the range that may be expected:

Maximum relative magnetic permeability	1 450 to 730
Remnant magnetism	0.75 to 0.74 T
Coercive force	200 to 360 A/m
Hysteresis loss for B = 1 T	1.49 to 0.84 μJ/mm ³
Resistivity	24 to 26 μΩcm

The first value approximates to that which would be obtained in a mainly ferritic iron while the second value is typical of a mainly pearlitic iron.

ANNEX B (Foreword)

TYPICAL PROPERTIES OF BLACKHEART MALLEABLE IRON

B-0 The following information is given for the guidance to engineers and designers. It is not part of this standard and should not be used for acceptance purposes.

B-1 MICROSTRUCTURE

Blackheart malleable iron has a fairly uniform microstructure beneath the immediate surface and therefore its properties are relatively insensitive to section size. The mechanical properties are largely determined by the chemical composition of the ferritic matrix.

B-2 COMPRESSIVE STRENGTH

The stress/strain properties in compression are similar to those in tension. The proof stress value in

compression is, however, slightly higher than in tension because the onset of plastic deformation is delayed under compressive stress.

B-3 SHEAR STRENGTH

This is 0.9 times the tensile strength.

B-4 TORSIONAL STRENGTH

The torsional strength is 0.9 times the tensile strength. The proof stress value in torsion is 0.775 times the value in tension.

B-5 MODULUS OF ELASTICITY

A value of 168.9 kN/mm² is typical.

B-6 MODULUS OF RIGIDITY

A typical value is 67.6 kN/mm².

B-7 POISSON'S RATIO

A value of 0.26 is appropriate.

B-8 FATIGUE LIMIT (WOHLER)

The unnotched fatigue limit is about 0.45 times the tensile strength. The notched fatigue limit is about 0.6 times the unnotched fatigue limit.

B-9 HARDNESS

The hardness will generally be in the range from 110 to 150 HB.

B-10 IMPACT PROPERTIES

Blackheart malleable iron have ductile to brittle notched impact transitions starting at temperatures of -10°C to +30°C. If the transition temperature is based on the mean impact value in the transition range (fracture approximately 50 percent ductile) temperatures are approximately 40°C lower (that is -50°C to -10°C). In an unnotched impact test the corresponding transition temperatures are approximately 50°C lower than in a notched test. In the ductile range notched impact values of about 14 to 18 J are obtained using specimen to IS 1757:1988.

B-11 COEFFICIENT OF THERMAL EXPANSION

Up to 400°C the value will be about $10.0 \times 10^{-6}/^{\circ}\text{C}$ to $12.5 \times 10^{-6}/^{\circ}\text{C}$, the higher values being obtained at higher temperature.

B-12 THERMAL CONDUCTIVITY

This will be within the range from 45.6 to 49.0 W/m°C up to 500°C. The value falls with increasing temperature.

B-13 SPECIFIC GRAVITY

The specific gravity may be expected to be 7.35.

B-14 SPECIFIC HEAT

This in the range 0.50 to 0.69 J/g°C, the higher value being over higher temperature ranges.

B-15 MAGNETIC AND ELECTRICAL PROPERTIES

Maximum relative magnetic permeability	2000
Remnant magnetism	0.5 T
Coercive force	120 A/m
Hysteresis loss for B = 1 T	0.6 μJ/mm ³
Resistivity	30 μΩcm

ANNEX C

(Foreword)

TYPICAL PROPERTIES OF PEARLITIC MALLEABLE IRON

C-0 The following information is given for the guidance to engineers and designers. It is not part of this standard and should not be used for acceptance purposes.

C-1 MICROSTRUCTURE

The matrix structure of pearlitic malleable iron consists essentially of pearlite or other transformation products of austenite with much of the carbon present as temper carbon.

C-2 COMPRESSIVE STRENGTH

The stress/strain properties in compression are similar to those in tension. The proof stress value in compression is, however, slightly higher than in tension because the onset of plastic deformation is delayed under compressive stress.

C-3 SHEAR STRENGTH

This is 0.9 times the tensile strength.

C-4 TORSIONAL STRENGTH

The torsional strength is 0.9 times the tensile strength. The proof stress value in torsion is 0.75 times the value in tension for the lower grades decreasing progressively to about 0.7 times the value in tension for the higher grades.

C-5 MODULUS OF ELASTICITY

A value of 172.4 kN/mm² is typical.

C-6 MODULUS OF RIGIDITY

A typical value is 68.9 kN/mm².

C-7 POISSON'S RATIO

A value of 0.26 is appropriate.

C-8 FATIGUE LIMIT (WOHLER)

The unnotched fatigue limit is about 0.45 for the low tensile strength grade decreasing progressively with

increase in tensile strength reaching a value of 0.40 for the high strength grade. The notched fatigue limit is about 0.6 times the unnotched fatigue value.

C-9 HARDNESS

The hardness of pearlitic malleable iron castings increases generally with increasing proof stress value. For any particular grade there is a hardness range within which hardness will vary according to the method of material manufacture. The hardness range expected for each grade of material is indicated in the standard.

C-10 IMPACT PROPERTIES

The lower grades have good ductility and toughness. As the grade increases, impact transition temperature increases with sacrifice of some ductility and toughness. With the higher strength grade, depending on the method of material manufacture, the impact transition temperatures may be similar to those obtained in fully ferritic blackheart malleable iron but the impact values in the ductile range will be lower.

C-11 COEFFICIENT OF THERMAL EXPANSION

Up to 400°C the value will be about $10.0 \times 10^{-6}/^{\circ}\text{C}$ to $12.5 \times 10^{-6}/^{\circ}\text{C}$, the higher value being obtained at higher temperatures.

C-12 THERMAL CONDUCTIVITY

This will be within the range 38.5 W/m°C to 45.2 W/m°C up to 500°C. The value falls with increasing temperature.

C-13 SPECIFIC GRAVITY

The specific gravity may be expected to be 7.3.

C-14 MAGNETIC AND ELECTRICAL PROPERTIES

The values given are typical of the range that may be expected and actual values will depend on the material grade and its method of manufacture. The first values refer to low strength and the second values to high strength grades:

Maximum relative magnetic permeability	800 - 200
Remnant magnetism	0.6 - 0.9 T
Coercive force	480 to 1 750 A/m
Hysteresis loss for B = 1T	1 to 3 $\mu\text{J}/\text{mm}^3$
Resistivity	34 $\mu\Omega\text{cm}$

CONVERSION FACTORS

Moduli of elasticity and rigidity:

$$1 \text{ MPa} = 1 \text{ N/mm}^2 = 1 \text{ MN/m}^2 = 0.102 \text{ 0 kgf/mm}^2$$

Impact properties:

$$1 \text{ J} = 1 \text{ N.m} = 0.102 \text{ 0 kgf.m}$$

Thermal conductivity:

$$1 \text{ W/m}^{\circ}\text{C} = 2.388 \text{ 46} \times 10^{-3} \text{ cal/cm }^{\circ}\text{C}$$

Specific heat:

$$1 \text{ J/g}^{\circ}\text{C} = 0.238 \text{ 846 cal/g}^{\circ}\text{C}$$

Magnetic and electrical properties:

1 T	=	10 000 gauss
1 A/m	=	$1.256 \text{ 28} \times 10^{-2}$ oersteds
1 $\mu\text{J}/\text{mm}^3$	=	10 000 erg/cm ³

For more detailed conversions, see IS 786:1967.

Bureau of Indian Standards

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards Monthly Additions'.

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